U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 32.

SILOS AND SILAGE.

(Revised Edition.)

CHARLES S. PLUMB, B. S.,
Professor of Animal Husbandry, Ohio State University.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., November 15, 1902.

Sir: I have the honor to transmit herewith for publication copy for a revised edition of Farmers' Bulletin No. 32, on Silos and Silage, prepared by C. S. Plumb, professor of animal husbandry in the Ohio State University.

The increasing popularity of silage as a feeding stuff made this revision seem desirable. Considerable new matter has been introduced, and some of the old illustrations have been replaced by new and better ones, so as to make the treatment of the subject up to date in every respect.

Very respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

SILOS AND SILAGE.

HISTORICAL.

The preservation of green food in silos commenced more than one hundred years ago. In 1786 Symonds wrote of Italians preserving fresh leaves for cattle in casks and pits in the ground. In 1843 Johnston, an Englishman, published an article on preserving green clover, grass, or vetches in pits, basing his statements on observations made in Germany. Pits were dug 10 to 12 feet square and about as deep, the sides lined with wood, and a clay floor made. The green stuff was placed in the pit, and plenty of salt scattered over it from time to time. When the pit was full, the top was well salted and a close-fitting cover of boards was placed over it. Dirt to the depth of a foot or so was thrown on the cover to exclude air. In a few days, after the contents had fermented and settled, the cover was removed and more green fodder was thrown in and the cover again put on. In commenting on the contents of such a pit Johnston notes that the grass when thus fermented had the appearance of being boiled, had a sharp acid taste, and was greedily eaten by cattle.

In England, between 1860 and 1870, Samuel Jonas stored tares or rye, cut green and chopped, and fed the fermented material on an extensive scale.

Adolph Reihlen, a sugar manufacturer of Stuttgart, Germany, probably stored the first green maize in pits. He also preserved green beet leaves and beet pulp in silos with much success. He had lived a number of years in the United States, and on his return to Germany experimented with large dent corn, the seed of which he carried with him from this country. As the crop did not always mature in that climate, the green crop was pitted after the manner of the beet refuse. This work was conducted between 1860 and 1870, and the results were published in the German and French papers of the time. The use of the silo was strongly urged upon the people of France, and considerable attention was given to the subject. Many farmers built silos on the basis of Reihlen's experience. In 1877, A. Goffart, of France, wrote a book on "ensilage," which was translated into English and published in New York a year or two later.

The first to prepare silage in the United States were Manly Miles,

of Michigan, who built two silos in 1875; and Francis Morris, of Maryland, who commenced experiments in this line in 1876. One of the earliest experimenters with silage in the United States was John M. McBryde, whose investigations began at the University of Tennessee in 1879. Several other silos were also built by people in the Eastern States within the next few years. In 1882, in a report on silage by the United States Department of Agriculture, statements were published from 91 persons who had silos, 81 of which were in Atlantic seaboard States. No doubt numerous others were in use at that time.

At the present time the silo is found on many thousands of farms in the United States, especially in dairy regions, and it may be considered a well-established feature in American farm economy where stock feeding is practiced. In fact, the use of silage for beef cattle is meeting with more and more favor.

CONSTRUCTION OF SILOS.

The first silos made in the United States were of stone or brick. The walls were thick, very strong, and were covered with a smooth coat of cement on the inside. These were very expensive; consequently wooden silos were tried, and it was found that very satisfactory results could be secured with these at a much less cost than with stone or brick silos.

FORM OF SILO.

The two most desirable forms are round and square. The round silo contains the least amount of waste space, and has the greatest strength, for an equal pressure is distributed against the walls at every point from the center, so that it can not press out or bulge. Taking equal capacity into account, the round silo requires less lumber than the other forms. The square silo may be built to advantage in a corner of the barn, where it would not be advisable to place a round one. Rectangular silos have been quite generally discarded, while very nearly all those being built at the present time are round. It is not advisable to build other than round silos, unless to take advantage of a section of a barn or some special condition. While there is considerable yet to be learned on silos and silage, it is pretty well settled that the round form is the best and most economical.

MISCELLANEOUS SUGGESTIONS.

In constructing a silo it will be well to keep in mind the following points:

Depth of Silo.—The greater the depth the greater will be the downward pressure of the contents, thus forcing out air and insuring better silage. Shallow silos as a rule give less satisfactory results than deep ones, as there are larger air spaces in the silage, owing to lack of pressure. Wherever practicable the silo should have a depth of not

less than 24 feet, while more satisfactory results may be expected if it is 10 feet deeper. If necessary the silo may extend 4 or 5 feet below the surface of the ground in order to obtain such a depth. It must, however, be borne in mind that good silos may be built 20 feet and even less in depth.

Smooth Walls.—After the silage is placed in the pit, it should settle evenly and easily. If the walls are perfectly vertical and smooth, the conditions for settling will be favorable. Where stone is used, a coat of water-lime cement must be used to make a good surface. As silage contains acid, this smooth surface will gradually become roughened, so that from year to year, as seems necessary, a light wash of cement should be brushed over the wall to make it smooth. Where wood is used, the lining boards should be dressed on one side. The wall on the inside should be perfectly plumb and smooth from the top of the silo to the foundation wall, from the top of which there may be a slight bevel to the floor. There should be no blocks or rods against the walls at any place to prevent the uniform settling of the contents. In any form of wooden silo, excepting the round, it is desirable that the inside lining boards be nailed on vertically. The silage will then slip down more easily than where it rubs against the edges of the boards nailed on horizontally.

Avoidance of Corners.—Upon the thoroughness of the packing usually depends the character of the preservation. Most of the waste which occurs where silage has been well put in occurs at the surface, against the doors, at the sides, and in the corners. The corners are difficult to pack well; hence a loss is often found there. One of the advantages of a round silo is the absence of corners. In the rectangular form the corners may be filled in with triangular pieces or boarded over for about 12 inches. If the foundation wall is only 2 or 3 feet high, it will be desirable to bevel from its upper inside edge to the floor, thus reducing the floor corners. If the door boards fit smooth and flush with the inside of the wall, there should be but little decay of silage there.

Inside Linings.—Where stone or brick is used, the final dressing should be of Portland cement with a very smooth finish. The contents of such a silo may be expected to keep well. King considers that such a cement lining will last ten years, and where a yearly washing of cement is applied it will last twenty or thirty years.

Lathed and plastered silos have not been a general success. In those cases known to the writer the plaster has suffered from cracking or has been injured by the fork. The plaster also softens from the acid of the silage. Moisture finally makes a passage through the plaster and injures the woodwork, which begins to decay.

Inside linings of sheet iron or roofing tin are not entirely satisfactory. The metal rusts, even if coated with paint or coal tar, since it is

difficult to prevent abrasions of the coat during the season of use. Further, the action of the acid injures the efficiency of the paint for the purpose intended. Roofing tins usually are coated with lead, from which deleterious effects may be expected, as the lead compounds are poisonous. At the Wisconsin Station two silos were lined with metal—one with tin and the other with sheet iron—and these linings were discarded after a brief trial as unsatisfactory.

The best inside lining for wooden silos consists of two layers of boards with a good quality of tarred paper between. This should be a waterproof and acid-proof paper, such as builders are more or less familiar with. The first layer of boards should be placed horizontally against the studs. Over this the paper should be placed in such a manner as to lap several inches where the sheets come together. Laths lightly tacked at intervals will hold the paper in position until covered with the second layer of sheeting. If the silo is other than round, then the second layer of lining boards may be nailed on vertically to advantage. If round, then the second layer should go on horizontally, with the boards nailed so as to break joints with the first layer. One-half inch thick and 6 inches wide are desirable dimensions for lining boards. No. 1 fencing ripped to form half-inch boards will do, or 2-inch planks may be sawed with still greater profit. Lumber for inside linings should be free from holes and knots, should be of good quality and well seasoned, and the boards should be of uniform width so as to match properly.

The Floor.—The floor of the silo may be made of stiff clay with some grout work in it to keep rats from burrowing up into the silage. If clay is not available, 3 or 4 inches of grout should be laid. The main object is to make a firm, smooth, close, rat-proof floor. A layer of concrete is highly recommended.

Ventilation.—The walls of wooden silos remain sound longest when they are well ventilated. Where they are carefully boxed up, moisture accumulates within and decay occurs. Auger holes bored between studs at the bottom give sufficient ventilation, if there are openings at the top of the wall. All these holes or openings should be covered with wire screen to keep out rats and mice. The studs should be strong, so as to guarantee against springing under the great pressure to which they are subjected.

The Doors.—An extra stud should be placed on each side and against the studs where the feeding doors are to come. The doors should be in line one above another between the double sets of studs, and about 2½ feet apart. Leave a stud between the two sets of double studs. This can be cut out later at the door spaces, while the part remaining will strengthen the wall. To make the opening, the layers of sheeting should be cut out between the double studs for a space 30 inches high or more. These doors placed at proper intervals should extend from the sill to within 3 or 4 feet of the top. The doors should be fitted

with casings and may be closed with boards cut as long as the door is wide and placed in horizontally, so as to be flush with the inside lining and resting against cleats nailed to the casings. Or doors may be made flat of tongued and grooved flooring, one layer crossing the other, and the two firmly nailed or screwed together, with a layer of tarred paper placed between them (fig. 1, *f*); or they may be made to fit the curvature of the wall (fig. 4). The door should be neatly fitted into the casing, so as to come flush with the inside lining, and may be held firm by large screws or lag bolts passing through blocks, which are bolted to the studs on each side of the door. A layer of tarred paper should be put on so as to cover the door and extend some distance out over the inner lining of the silo.

The Foundation.—The foundation wall should be at least 12 inches above the surface, and should extend below the frost line, say, 2 to 3 feet in the North. The wall should be air-tight, and for silos 25 to 30 feet deep a thickness of 1½ to 2 feet is desirable. It is desirable to have the silo partly below the surface, but not to such an extent as to make emptying difficult; 4 or 5 feet below will not be an inconvenient depth. Water should not drain into the silo from without, and if danger from this source exists proper drainage should be provided at the time of construction.

Weatherboarding.—It is not essential to place weatherboarding on the outside of the silo to preserve the contents. The cost of the dressing outside of the studs is thus saved, but a silo so left is not an attractive-looking farm building. It is important to note also that in the colder parts of the country, where severe freezing occurs, a good covering outside of the studs reduces the freezing. Warm silage is more palatable than that permeated with frost. For these reasons weatherboarding is recommended.

The Sills.—These should be well tarred, should rest on a good foundation, and be bedded in cement or mortar. It is important to have sills well above the soil on the outside, and at least a foot above the floor on the inside. In the square-cornered forms they should be anchored to the wall so as not to spread. This is usually accomplished by placing strong bolts in the wall when laying it, arranged to extend up through the sill (see fig. 5, p. 17). This is unnecessary with round silos.

The Roof.—A roof is required only on silos built out of doors, independent of buildings. Even then it is not a necessity. Many silos have been constructed in recent years and left unroofed. Neither rain nor snow will damage the silage, but in localities where much snow falls, it furnishes an objectionable addition to the feed. In the writer's opinion, after extended experience, a roofed silo is preferable to an open one. The cost of the roof is largely a matter of taste. Some erect silos adjacent to barns, and then place lean-to roofs over them. If a close roof is constructed, then a cupola or window should be built

in it with a view to providing ventilation. A dormer window or door in the roof is also necessary, through which to fill the silo. Such a door or window should be wide enough to admit the end of the carrier or blowing tube and allow a person to pass in beside it.

Painting or Tarring the Silo.—This is advisable under some circumstances, and perhaps not under others. Formerly it was recommended to paint the woodwork with hot gas tar, this being a good wood preservative. More recent observation seems to indicate that, where the inside of the wooden silo is tarred, the tar has an injurious effect in retaining the moisture of the silage in the wood longer and thus promoting decay. Consequently, some men of extended experience in silo construction no longer paint the walls of stave silos. Where the walls are hollow, with sheeting on both sides of the studs, the outer covering may be painted to advantage if desired. The inner wall however should not be painted or tarred.

Capacity of the Silo.—The capacity of the silo should depend on the needs of the farmer. A cubic foot of silage under average conditions will weigh 35 to 40 pounds. Ordinarily, this amount is enough, with other food, for a day's feeding for one cow. A beef animal should not be fed quite so heavily as a dairy cow, and 50 pounds is ample for a heavy milker. If silage is fed one cow two hundred days, she will consume 8,000 pounds, or 4 tons. Ten cows will consequently require 40 tons. Allowing for some waste and emergency conditions, 50 tons would be a liberal estimate for a herd of this size.

The following table adapted from Bulletin No. 59 of the Wisconsin Station, by King (using round numbers only) shows the approximate capacity of round silos:

The approximate capacity in tons of round silos for well-matured corn silage.

Depth of silo in feet.	Inside diameter of silo in feet, and capacity in tons.[a]											
	15	16	17	18	19	20	21	22	23	24	25	26
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
20	59	67	76	85	94	105	115	127	138	150	163	177
21	63	72	81	91	101	112	123	135	148	161	175	189
22	67	77	86	97	108	120	132	145	158	172	187	202
23	72	82	92	103	115	127	141	154	169	184	199	216
24	76	87	98	110	122	135	149	164	179	195	211	229
25	81	92	104	116	129	143	158	174	190	206	224	242
26	85	97	110	123	137	152	167	184	201	219	237	257
27	90	103	116	130	145	160	177	194	212	231	251	271
28	95	108	122	137	152	169	186	205	223	243	264	285
29	100	114	128	144	160	178	196	215	235	256	278	300
30	105	119	135	151	168	187	206	226	247	269	292	315
31	110	125	141	158	176	195	216	236	258	282	305	330
32	115	130	148	166	185	205	226	247	270	295	320	346

[a] As the silage becomes more and more compact as the material settles and the pressure from above increases, the weight per cubic foot increases with the depth, being less than 20 pounds at or near the surface, and about 60 pounds at a depth of 35 feet. It is evident, therefore, that the average weight per cubic foot of silage is greater in a deep than in a shallow silo. For instance, the average weight per cubic foot in a silo 16 feet deep is about 30 pounds, while in a silo 32 feet deep it is about 40 pounds. At the Wisconsin Experiment Station, from actual weights and measurements of corn silage at different depths, a scale of weights per cubic foot was made up (see Bulletin No. 59 of that station), and this scale was used in computing the capacities shown in this table.

The figures in the body of this table show the capacities in tons of silos having the depths given in the column on the left and the diameters given across the top. Thus a silo 20 feet deep and 20 feet in diameter has, according to the table, a capacity of 105 tons. The table should be of considerable service to persons contemplating building. One may readily ascertain his own silo needs by figuring on the amount of silage his stock will consume per day during the feeding season, or say, one hundred and eighty days. One mature cow will consume to advantage from 25 to 50 pounds per day, depending on size and conditions. A beef animal should not be fed quite so heavily as a dairy cow, and 50 pounds is an ample feed for a heavy milker, particularly as all cattle should also be fed hay as well as silage. In using the figures given in the table, however, it should be borne in mind that they show the capacities of silos could they be filled with settled silage, but this is a condition which it is practically impossible to secure, even with the most careful filling and refilling. Allowance should therefore be made for unavoidable settling in determining the size of the silo to be constructed.

ROUND SILOS.

As has already been stated, the round form is, all things considered, the most desirable. This type has two features of great advantage over others: (1) There are no corners to promote decay; and (2) the pressure from within is very uniformly distributed so that bulging sides do not occur, as is so often the case with silos having straight sides and square corners.

Wisconsin Round Silo.—This is one of the very best and most durable of the wooden kind. The accompanying illustration (fig. 1), republished by permission from Bulletin No. 59 of the Wisconsin Experiment Station, shows various features of the construction of this silo. The silo extends several feet below the surface of the ground (fig. 1, *a*). A thick foundation wall of stone laid in cement (or of brick) rises a foot or more above the ground surface. Sill pieces 2 inches thick may be cut in sections about 2 feet long; should be sawed with the proper curve and be 4 inches wide; should be bedded in mortar or cement on top of the foundation wall at its outer edge; and should be toe-nailed together. The top of the foundation wall, which slopes downward from the edge of the sill to the inner edge of the wall, is covered with cement and made smooth (fig. 1, *d*). Plates of the same description as the sill pieces are spiked to the tops of the studs. For studding 2-by-4's are set 12 inches apart from center to center. If the silo is to be made 28 feet in height from top of foundation wall, studs 16 and 12 feet in length may be used alternating—that is, using first a 16-foot stud, then a 12-foot one in building the lower part, and for the upper part placing a 16-foot stud on the top of each 12-foot stud, etc.

The studs should be toe-nailed to the sill flush with its inner edge, and should be set and kept plumb. The studs of the first round may be held in place by nailing a piece of sheeting on the outside temporarily as high up as a man can reach. Scaffolding may be erected on the inside with little trouble. The inside lining (fig. 1, *d*) consists of a layer of ½-inch sheeting nailed to the studding, a layer of tarred paper on this, and a second layer of ½-inch sheeting so put on as to break joints with the first. Both layers of sheeting are put on horizontally. The walls may be ventilated (fig. 1, *e*) by openings in the

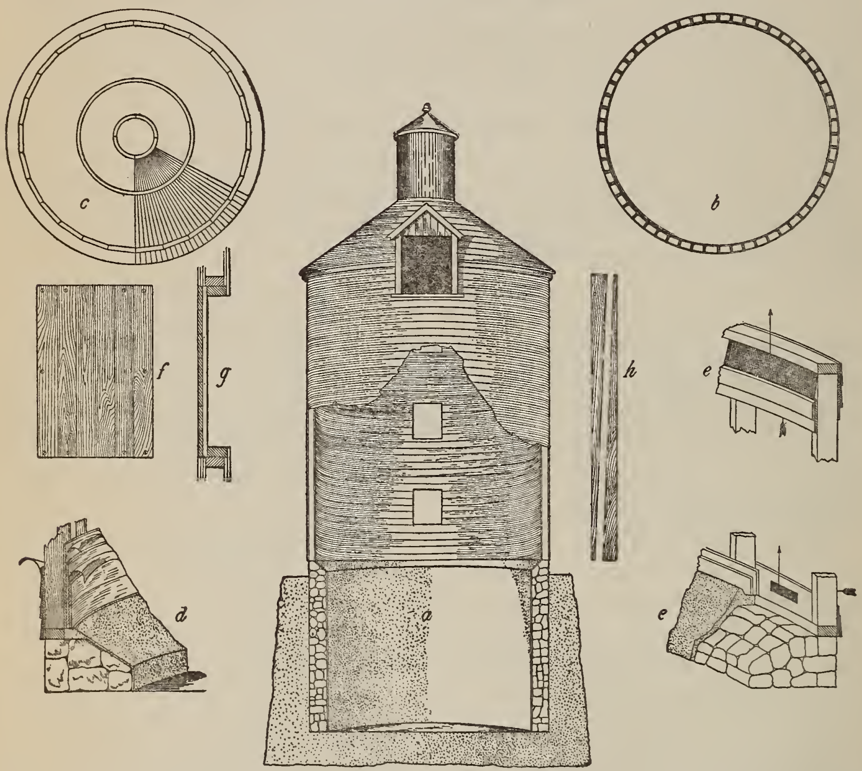

Fig. 1.—The Wisconsin round silo: *a*, interior view; *b*, cross section; *c*, roof, from below; *d*, top of foundation wall, sill, studs, and two layers of sheeting with tarred paper between; *e*, *e*, method of ventilating wall; *f*, door; *g*, door fitted into opening; *h*, boards for roof.

weatherboarding between studs at the bottom and openings in the inside lining at the top. The cupola should be so constructed as to allow free passage of air from within. Rafters are not used in making the roof, but, instead, circles made by bending and nailing together strips of ½-inch lining so as to make a hoop or circular plate 4 inches thick (fig. 1, *c*). Roof boards (fig. 1, *h*) may be made by ripping an 8-inch common board diagonally so as to make two boards, about 6¾ inches wide at one end and 1¼ inches at the other. The filling door at the top should be 3 feet wide, so as to allow a man to enter by the side

of the carrier or blower. The feeding doors (fig. 1, *f*) should be fitted in as shown in figure 1 at *g*.

A modified form of the Wisconsin silo may be adopted in case it is

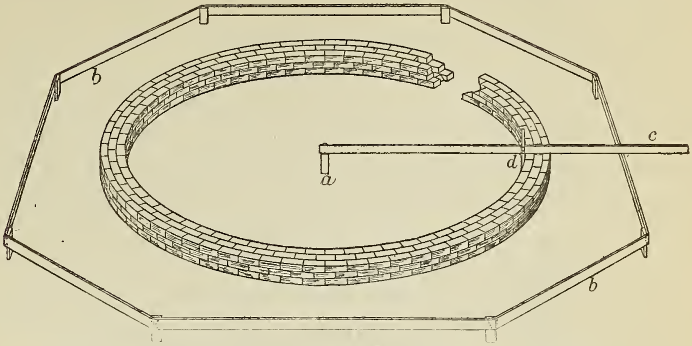

FIG. 2.—Method of laying and leveling foundation of round silo.

desired to reduce the cost to a minimum. Without making any excavation whatever, a foundation can be built of three or four

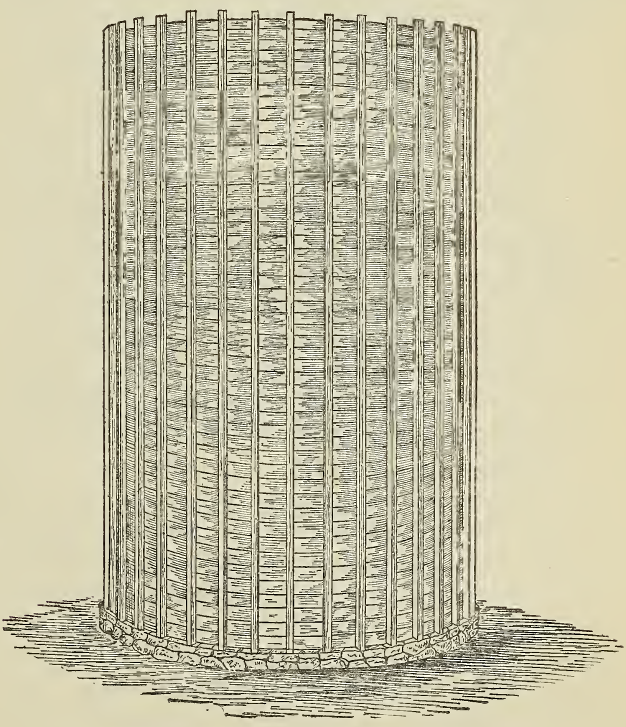

FIG. 3.—Cheaper form of Wisconsin round silo.

courses of brick. A simple contrivance for use in building such a foundation, whether of brick or stone, is shown in figure 2. A center post (*a*) is driven in the ground, its top remaining as high as it is

desired to make the foundation wall. Around this, at a distance of 10 or more feet, are driven a number of similar posts, whose tops should be level with that of the center post. To these are nailed straightedge boards (*b*, *b*). Then a piece of straightedge board (*c*) is fixed on a pin or nail driven in the top of the center post so as to turn freely. A mark or small crosspiece (*d*) on this stick will, when the stick is turned about on *a*, describe a circle which locates the inner edge of the wall. The construction above the foundation is the same as in the silo already described, except that the outside covering of boards and the roof are omitted (fig. 3). In this way a silo can be made which is cheap, strong, and fairly satisfactory. Where the soil is heavy and the drainage is good, a cement floor can be dispensed with. A silo of this description of 150-tons capacity, having a good roof and foundation, was built on an Indiana farm at a cost of $107 for material and labor.

The Stave Silo.—Since 1895 the stave silo has come into great popularity, so much so that several firms are manufacturing them as a regular business, shipping them to all parts of the United States, to be set up by the purchaser or local talent. Such silos are usually well constructed of high-grade material. Most stave silos, however, are homemade.

In the construction of the stave silo the following suggestions will be found of value: Construct a substantial foundation, sunk deep enough not to be moved by the action of frost. If two staves are used to give the height of silo, saw the ends of butting staves, so that a strip of galvanized iron sheeting, 2 inches wide and as long as the stave is wide, may be inserted one inch in the end of each stave, to hold them together. The staves should be of superior timber 2 inches thick and 5 or 6 inches wide. They should be dressed on one side—that which forms part of the inner wall—and are better for being dressed on all sides. Band iron or round iron may be used for hoops, the latter generally receiving preference, offering less friction in tightening or adjusting than the wide flat band, and presenting less surface to rust. Hoops of five-eighths-inch round iron with three-fourths-inch ends are recommended. To facilitate tightening, it is well to have the hoops in two or three sections. Woven wire fence may take the place of hoops. A narrow width of any good standard pattern should be cut so as to give the necessary length to go about the silo, and each end should be securely wound and fastened about a 4-by-4 piece as long as the fencing is wide. Holes should be bored through the 4-by-4's suitable for half-inch or larger bolts. When the fencing is placed about the silo, the sides of the 4-by-4's should be about 6 inches apart. The bolts are then pressed through the two pieces of wood, washers and nuts are placed thereon, and the blocks of wood are drawn toward each other, thus tightening the staves.

In silos two staves high the staves should be of two lengths, and the longer and shorter should alternate in the construction. The lower course of staves should be erected first, and may be held in place by stapling to two hoops, one near the ground, the other toward the top of the shorter staves. The staples should not be driven in full length, but loosely, to permit future adjustment. Each stave should be kept perpendicular. Set the inner face of the line of staves about an inch back from the inner face of the foundation wall, and before filling bevel the angle on top of wall with cement, to keep staves in place. Also cement about staves on the outside along the top of the wall. On

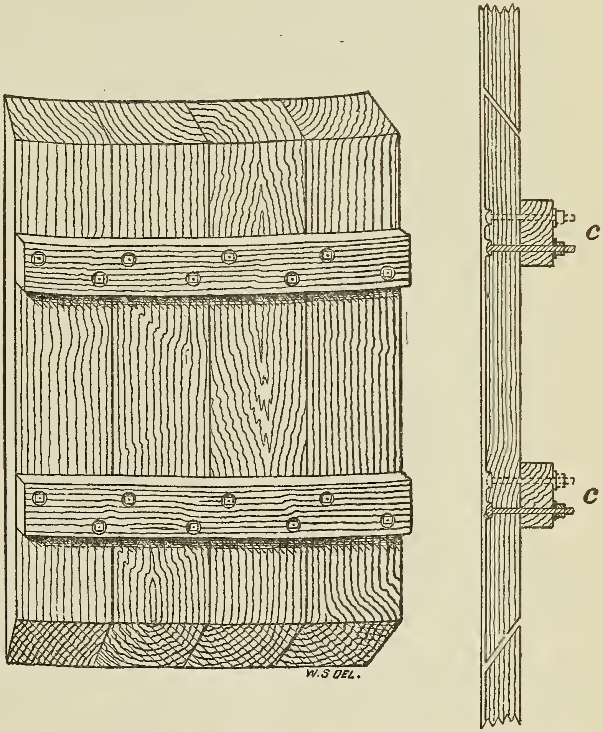

Fig. 4.—Door of stave silo. The cleats c c are on outside of door.

the lower two-thirds the hoops should be placed about 2½ feet apart. Above that they may be wider apart.

In constructing the silo, when the place is reached where tne doors are desired, one stave should be sawed nearly through in the right place for the top and bottom of each door, cutting with the saw a bevel of about 45 degrees. When the construction of the wall is finished, the saw may be inserted at the points where the staves have been partly sawed and the other staves may be sawed through to secure a door of the desired width. The pieces sawed out of the staves should be used in making the doors. Two cleats 2 or 3 inches wide

and long enough to reach across the door may be sawed with the proper curvature from 2-inch plank and firmly bolted to the sections of the staves before they are sawed out (fig. 4). When the silo is filled, two thicknesses of tarred paper should be tacked over the entire inner surface of the wall, including the doors.

Stave silos are not as satisfactory as the Wisconsin round form. Staves shrink and swell and require attention and adjustment from time to time. Many stave silos have blown over or been blown out of plumb when in the open, or have buckled when set too tight previous to filling or moistening. King claims that the loss from imperfect preservation is too high in the stave silo, ranging from 23 to 28 per cent. Stave silos of large diameter are undesirable. Perhaps 15 feet is as wide as they should be made. Undoubtedly two small deep silos are preferable to one large one.

Cement or Grout Silos.—Some attention is at present being directed toward cement or grout silos, more especially in certain sections of Canada, where they have met with favor. Such silos are made in wall sections with the aid of frames or "cribs." The walls of these silos are much thicker at the bottom than at the top, 18 inches being regarded as a satisfactory thickness at the base and 9 inches at the top. Stay rods laid in the wall at intervals and following its curve are regarded as advisable, as they strengthen the wall and prevent its cracking. Such rods should have angles on the ends, and should be placed in the spaces between the doors. In general grout work, one part cement to nine of gravel will answer, if the gravel is good, while for plastering the inside or outside one part Portland cement to two of clean sand is recommended. The cost of such silos varies, but in Canada one man gives the cost of one 30 feet high and 14 feet inside diameter as $162.50, including cost of roof, which was $15.

Brick and Stone Silos.—Brick and stone were used in the early days of silo construction in this country, after which came the wooden forms. Recently attention is again being directed to the more durable silos of brick or stone. Quoting from a recent bulletin by the writer,[a] it is recommended that the following points be guarded:

> Make the foundation of stone, if practicable, and let the first course of brick come flush on the inside with the stonework. Bed a $\frac{5}{8}$-inch iron hoop in the stonework in the upper part before laying the brick, in order to keep the pressure of brick from spreading the wall before the mortar becomes set and hard. Make a 2-inch air space in the walls up to within one-third of the top. This will make a 14-inch wall of 3 courses of brick. If, however, the silo is to be over 24 feet inside diameter, then a 4-brick wall is really necessary one-third the way up, three for the next third, and two for the upper third. The air space should be in the outer part of the wall. Iron tie-rods should also be laid around in the wall between the doors, as recommended for stone work. It is also important that the brick shall be wet when laid, otherwise the mortar in which they are laid will be dried out too rapidly. The walls should be plastered over very smoothly with a coat of rich cement, one-fourth to one-half inch thick.

---

[a] Indiana Sta. Bul. 91.

King recommends that the door jambs be made of 3-by-6's or 3-by-8's, rabbeted 2 inches deep to receive the door on the inside. The center of the jambs outside should be grooved and a tongue inserted projecting three-fourths of an inch outward to set back into the mortar, thus securing a thoroughly air-tight joint between wall and jamb.

A stone silo should have a wall about 2 feet thick below the surface, and below the ground level it may be laid in cheap cement. Above it should be laid in a good grade of Portland cement. The wall above the surface may be of much the same diameter as the brick silo. Iron holding rods should also be used in the construction of the stone silo, to prevent its spreading or cracking. Short lengths of rod with overlapping angled ends may be used to best advantage.

RECTANGULAR SILOS.

The sills should be made of two 2-by-10-inch plank spiked together (fig. 5). These may be anchored to the brick or stone foundation by means of bolts bedded in the foundation and passing up through the

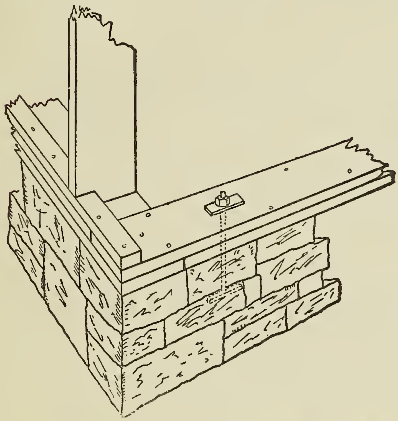

FIG. 5.—Lower corner of square silo, outside view.

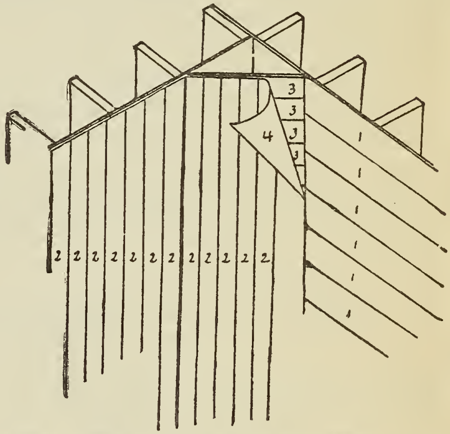

FIG. 6.—Upper corner of square silo, inside view: 1, first inside lining; 2, second inside lining; 3, lining across corner; 4, tarred paper between linings.

sills. A 2-by-4 should be spiked on top the sill flush with its outer edge, and against this the studs should be blocked. The studs should be 2-by-10 inches and should be placed 18 inches apart. If the silo is to be more than 20 feet deep, 2-by-12 pieces instead of 2-by-10's should be used for studs, on account of the greater pressure. On top of the studs are spiked strong plates. Silos of this type should be tied across the top by joists or cables to opposite studs to keep the walls from spreading. In a silo 15 feet long two ties will be ample, and one may do. For the inside lining (fig. 6) No. 1 fencing stuff should be nailed on horizontally, beginning at the bottom; over this should be placed a layer of tarred paper; and lastly a second layer of plank is nailed on vertically. Partitions are objectionable unless in shallow silos. They reduce storage space, are inconvenient, and along the walls and in the corners caused by them usually occurs more or less waste from decay of silage.

14399—No. 32—03——2

COST OF SILOS.

The cost of a silo depends entirely upon local conditions. The cost of materials and labor varies widely with time and place, and it is, therefore, impossible to make an estimate which shall have any permanent or wide application. A cheaply made silo may be a desirable investment under some circumstances, but it is generally best that the silo be made of high-grade stuff and be well and strongly built. Poorly constructed silos may be expected to result in an unreasonable loss of the contents, which will add to the ton cost of the silage. The very reason why some persons have condemned the silo is that they have built silos improperly and have suffered considerable losses from decay.

King says the good silo will save from 15 to 25 tons more silage in good condition out of every 100 tons than the poor silo can, and counting silage at the nominal price of $1 per ton, we have an interest of $15 to $25 on $150 every year.

Rather than give any exact figures for cost of construction, such as were given in the first editions of this bulletin, the author deems it wiser to introduce estimates of materials for constructing silos of four types. A slight excess of material is allowed for construction. These statements are so constructed that the reader may fill out against each line the cost of materials in his locality, and may thus ascertain the cost of a silo, excepting labor, under his local conditions:

No 1.—Estimate of material for a Wisconsin improved round silo, 30 feet deep, 14 feet in diameter, and having a capacity of 90 tons.

	Cost.
Brick for foundation, 1 foot thick and 3 feet deep, 3,375	
Studs, 2 by 4, 16 feet long, 50 pieces	
Studs, 2 by 4, 14 feet long, 50 pieces	
Flooring for doors, 32 feet	
Sheeting, half-inch (resawed from 2-by-6 plank, 16 feet long, sawed three times), dressed on one side to uniform thickness for inside lining of two layers, 3,000 feet, and for weatherboarding for the outside, 1,500 feet; in all 4,500 feet	
Tar building paper, water and acid proof, 200 yards	
Nails: 8-penny, 200 pounds; spikes, 20 pounds; shingle nails, 12 pounds	
Rafters, 2 by 4, 10 feet long, for ridge roof, 22 pieces	
Sheeting for roof, 16-foot boards, 350 feet	
Shingles, 3,000	
Dormer window for filling through	
Paint for two coats, 7 gallons	
Cement for cementing bottom, 2 barrels	
Total cost	

No. 2.—Estimate of material for modified Wisconsin silo of same capacity as No. 1.

	Cost.
Brick for foundation, 8 inches wide and 6 inches high, 375	
Studs, 2 by 4, 16 feet long, 50 pieces	
Studs, 2 by 4, 14 feet long, 50 pieces	

	Cost.
Sheeting, half-inch (resawed from 2-by-6, 16-foot plank, sawed three times), dressed to uniform thickness, for inside lining of two layers, 3,000 feet	
Tar building paper, water and acid proof, 200 yards	
Nails: 8-penny, 150 pounds; spikes, 12 pounds	
Total cost	

No. 3.—Estimate of material for stave silo, 12 by 28 feet, with a capacity of 60 tons.

	Cost.
Brick for foundation, 1 foot thick and 2 feet deep, 1,800	
Staves, 2 by 6, 16 feet long, dressed on four sides, 77 pieces	
Staves, 2 by 6, 12 feet long, dressed on four sides, 77 pieces	
Rods, 19½ feet long, of ½-inch iron, with ⅝ threaded ends and nuts, 20 pieces	
Staples, ½ by 2 inches, 2 gross	
Iron tighteners for holding ends of hoops, 20	
Rafters, 2 by 6, 14 feet long, for roof[a] center, 2 pieces	
Rafters, 2 by 6, 13 feet long, for roof, next to center, 2 pieces	
Side rafters, 2 by 4, 48 feet	
Roof sheeting, common, 170 feet	
Tin sheeting, 196 feet	
Cement for floor, 2 barrels	
Total cost	

No. 4.—Estimate of material for square silo, 15 by 15 feet inside, 20 feet deep, with a capacity of 94 tons, to be built within barn.

	Cost.
Cement, Portland, 3 barrels	
Foundation, 3 by 1½ feet by 66 feet	
Sills, 2 by 12, and 18 feet long, 8 (144 linear feet)	
Studs, pine, 2 by 10, 82 pieces (half 8 and half 12 feet long)	
Lining, No. 2 fencing, 1,400 feet	
Lining, No. 1 fencing, 1,400 feet	
Top plate, 2 by 8, 16 feet long, 4 (66 linear feet)	
Tarred paper, 1,400 feet surface	
Nails, 100 pounds	
Total cost	

SELECTION AND CULTURE OF SILAGE CROPS.

The plants most available for silage in the United States are Indian corn, red clover, rye, oats, wheat, sorghum, the millets, alfalfa, and soy beans and cowpeas in addition to the above in the South.

Indian Corn.—This is the great silage plant of America. It is adapted to a wide range of latitude and longitude, and will produce the largest amount of desirable silage per acre of any crop we can grow. Fifteen to twenty tons of green fodder can be grown on an acre without difficulty over a large part of the United States.

All the large varieties of corn are suitable for silage, but some are preferred to others. The important point is to secure as many tons of

[a] The estimates are for a flat tin roof with a central section across the top which may be swung over during filling.

food per acre as is possible. The larger dent varieties are the favorite ones for silage. Burrill and Whitman is one of the best known varieties, but for regions in the northern corn belt it does not mature soon enough to be entirely satisfactory. As a rule, the best corn for the silo, in any locality, is that variety which will be reasonably sure to mature before frost, and which produces a large amount of foliage and ears. Wisconsin Yellow Dent does well on the northern line of dent corn growing, while Burrill and Whitman, Leaming, and Dungan White Prolific will do well farther south. The common Southern Horse Tooth and Mosby Prolific are well adapted to the Southern States, and are heavy yielders. It is a common practice now for owners of silos to draw upon the general cornfield to fill the silo, not planting any special variety for this purpose.

In preparing the soil only the best of tillage and cultivation should be practiced. The soil should be fertile to yield an abundant crop of strong plants. The seed may be planted in drills 1 foot apart, in rows 3½ to 4 feet apart, according to locality.

Many experiments have shown that silage corn contains the most nutriment when the kernels begin to glaze, or when denting is well established, and before the lower leaves become dry. If cut before this period, too large a percentage of water is harvested in the crop, while the greatest development of food substance in the plant has not yet been reached.

The following table shows the amount of water and nutrients in an acre of corn at different stages of development, as shown by investigations at the State experiment station at Geneva, N. Y.:

Total yield and amount of water and nutrients in an acre of corn.

Time and stage of development.	Total green crop.	Water.	Dry matter.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Ash.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
July 30, in tassel	18,045	16,426	1,619	239.8	514.2	653.9	72.2	138.9
Aug. 9, in silk	25,745	22,666	3,078	436.8	872.9	1,399.3	167.8	201.3
Aug. 21, milk stage	32,600	27,957	4,643	478.7	1,262.0	2,441.3	228.9	232.2
Sept. 7, kernels glazed	32,295	25,093	7,202	643.9	1,755.9	4,239.8	260.0	302.5
Sept. 23, fully ripe	28,460	20,542	7,918	677.8	1,734.0	4,827.6	314.3	364.2

This table shows that when the plant is fully ripe we secure the greatest amount of dry matter, albuminoids, nitrogen-free extract, ether extract, and ash, with less water than at either of the three prior stages.

Red Clover.—Red clover, if well preserved, makes very superior silage. A few years ago this plant was used for silage much more than now. It is difficult, however, to preserve it without considerable loss, and much clover has been lost in silos. This is in considerable measure due to the high fermentation it goes through soon after being placed

in the silo. If one wishes to place clover in the silo he should allow the plant to mature well, not cutting till the blossoms are partly browned. The crop should be cut when free of dew, or nearly so, and placed in a deep silo and well packed. The clover may be put in the silo whole or cut, as desired. Corn makes a far more reliable silage than clover, and yields more bountifully per acre.

Sorghum and Kafir Corn.—Sorghum has not proven as satisfactory as corn for silage, but this or Kafir corn may be used as a substitute for corn where the latter crop is unreliable from drought, as in the Southwest, for example. Sorghum is not so nutritious as Indian corn. The stalks are more dense and the silage is not relished quite as well by cattle as that from corn.

Cowpeas and Soy Beans.—Cowpeas produce a large amount of very nutritious food. In the South and more temperate Central West large crops of cowpeas may be grown. Placed in the silo alone, this crop is not entirely satisfactory. Placed in the silo with corn in alternate layers, the results are excellent. As these two plants may be matured in the South at about the same time, they offer a valuable combination for Southern feeders. What has been said of cowpeas applies also to soy beans, which make excellent silage and have the advantage of being more easily handled. They can also be grown successfully much farther north than cowpeas. The larger, coarser-growing varieties, which yield heavy crops of forage, should be selected.

FILLING THE SILO.

When corn is used, the entire plant, including the ear, should be placed in the silo. On small farms much corn is cut for the silo by hand. In the great corn districts, however, the self-binding harvesting machine has come into extensive use. A cheap form of corn harvester may be made in the form of a sled, with knives fastened to the edges, so that when drawn by a horse between two rows the knives cut off the stalks near the ground. One or two men ride on or walk beside the machine and gather the stalks into armfuls as cut, and place them on the ground or on a wagon, as convenient.

Numerous forms of wagons are used for carrying the crop from the field, but it is desirable to use a low wagon, so as to save as much lifting as possible. Wagons of this character are sold in the market, or one can have special small wheels with tires 4 to 6 inches wide made for use on a common farm wagon.

At one time it was considered advisable to allow the corn to wilt in the field before putting it in the silo, it being thought to keep better. This practice is no longer considered important, and many silos are now filled most successfully as fast as the crop can be drawn from the field and cut.

Rapidity of filling is unimportant, so long as fresh fodder is placed in the silo before mold is formed at the surface.

Corn may be placed in the silo uncut, but this practice is objectionable. The stalks will not pack as closely as the cut fodder, and it is not so convenient to handle or economical for feeding purposes. The fodder cutter should be placed so as to deliver the cut material as near the center of the silo as possible, so that it may be distributed evenly therein. A useful device to be used in distributing the silage as it comes from the carrier or blower tube is a long cloth tube made of common sacks stitched together end to end. One end of this tube should be attached at the top so as to catch the silage and the lower end should reach nearly to the surface of the silage. This flexible tube can be swung around so as to throw the cut feed where desired, the attendant meanwhile tramping it down. As the silo fills, the tube can easily be shortened by removing sections. This device makes the work easier and adds much to the comfort of the man working in the silo.

Until quite recently most silos have been filled by running the cut crop from the cutter knife onto an open carrier consisting of slats and canvas cloth fastened to an endless chain passing over sprocket wheels operated by gearing connected with the fodder cutter. This carrier extends over the top of the silo, and the slats keep the green material constantly moving into the pit. This open carrier, however, is cumbersome; the chain or the slats frequently break or get out of gear, and, if windy weather prevails while filling is in progress out-of-doors, much of the light, chaffy stuff is blown off before reaching the top of the silo.

Quite recently a new method has come into successful use. With a "blower" it is possible to force the cut feed through a galvanized iron tube some 8 inches in diameter into the silo. The writer has made use of this method with entire success, as have many others. The chief objection to the use of the blower is in the power necessary to run the combined cutter and blower. A 15-horsepower engine is probably equal to the average demand for power for this work. If one owns or can hire such a power, it will be found desirable to use the blower. When using a blower, however, it is highly important to feed carefully and in uniform amount what the machine can easily force up the tube, or it may become clogged just beyond the knife. Carriers or blowing outfits may be purchased of most firms manufacturing fodder cutters. The shorter the fodder is cut the more satisfactory it is for feeding. One-half inch is a very common length. Or the fodder may be shredded instead of being cut.

Close packing and careful exclusion of air from the mass of the silage are of great importance. Investigations made at the Wisconsin Station have shown that with loose packing the loss of silage was three times as large as with close packing and that, when mature crops are used and special care is taken to pack the material closely to exclude the air as completely as possible, the unavoidable losses need not exceed 4 to 8 per cent. It is, therefore, desirable to have a

careful person inside the silo to distribute the fodder and trample it well at the corners and along the sides, in order to have the contents evenly and thoroughly packed. The silo should be filled above the top, as the silage will settle considerably below it during the process of fermentation or heating. Temporary boards may be placed above the edge for a few days, or fresh silage may be added to fill up the space as the settling goes on, provided the contents have not molded at the surface.

It will be unnecessary to place any weight on the silage after filling. Feeding may begin from the silo at once, or if this is not desired, then a layer of chaff or cut straw on the top a few inches deep will aid in keeping the top from molding.

Usually the contents of the newly filled silo contain enough water, but in very dry seasons it may be advisable to sprinkle the silage while filling.

COST OF SILAGE.

The cost of silage per ton will vary widely, according to size of crop, cost of labor, machinery employed, value of land, taxes, etc. In the writer's experience in the Central West, the cost on high-priced land has been about $1.50 per ton. Taking all the factors into account, F. S. Peer, in a recent book which treats of silos and silage (1900), gives the cost, in his experience, at about $1.20 per ton. Professor Woll, of Wisconsin, places it at $1 to $1.50 per ton, including cost of seed, preparation of land, interest on investment, cultivation of corn, cutting, and filling the silo. King, in studying this subject in Wisconsin, found that, for a number of farms of that State, the cost averaged only 73¼ cents per ton.

COMPOSITION AND FEEDING VALUE OF SILAGE.

Many analyses have been made of silage by chemists. The following table gives the amount of dry matter and digestible nutrients in 100 pounds of different kinds of silage, as published by Henry in his book on Feeds and Feeding:

Dry matter and digestible nutrients in silage from different crops.

Crop used for silage.	Total dry matter.	Digestible nutrients.		
		Protein.	Carbo-hydrates.	Ether extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Corn	20.9	0.9	11.3	0.7
Red clover	28.0	2.0	13.5	1.0
Sorghum	23.9	.6	14.9	.2
Alfalfa	27.5	3.0	8.5	1.9
Grass	32.0	1.9	13.4	1.6
Cowpea vines	20.7	1.5	8.6	.9
Soy bean	25.8	2.7	8.7	1.3
Barnyard millet and soy bean	21.0	1.6	9.2	.7
Corn and soy bean	24.0	1.6	13.0	.7

The economy in using a feeding stuff depends mainly upon its cost of production, palatability, digestibility, and influence on animal production. How much of the several components of different foods is digestible in equal amounts is a most important consideration. Allen gives the following as the number of pounds of digestible food ingredients in 100 pounds of green corn, corn fodder, and corn silage:

Dry matter and digestible nutrients in 100 pounds of corn fodder and corn silage.

Feeding stuff.	Total dry matter.	Digestible nutrients.		
		Protein.	Carbohydrates.	Fat.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Corn fodder (green)	20.7	1.10	12.08	0.37
Corn silage	20.9	.56	11.79	.65
Corn fodder (dry)	57.8	2.48	33.38	1.15

Using figures obtained in digestion experiments conducted by Armsby at the Pennsylvania Station, the following yields of digestible material are given for 1 acre of land, from which the same variety of corn was taken:

Digestible nutrients in corn from one acre.

Nutrients.	Green fodder.	Silage.	Field-cured fodder.
	Pounds.	*Pounds.*	*Pounds.*
Protein	251	233	202
Carbohydrates	3,947	3,164	3,030
Fat	153	263	156
Total	4,351	3,660	3,388

From this table it is seen that more digestible food per acre is secured from green fodder than from silage, and in turn from silage than from field-cured fodder. The chief deficiency of the silage occurs in the albuminoids, which are the most valuable food ingredients.

Numerous experiments have been conducted to show the relative digestibility of the corn plant dry or as silage. The difference in feeding value as based on these tests is small, though as a rule it slightly favors silage, it being more digestible than the dry fodder.

FEEDING SILAGE TO FARM STOCK.

The first general use of silage as a stock food was with dairy cattle. The extensive erection of silos in many parts of the country, however, has resulted in its adoption in the feeding ration by many breeders of horses, beef cattle, and sheep.

From a practical standpoint, the value of silage as food may be shown in several ways. It is as easily digested as the same plant preserved dry. It keeps the digestive system in a state of healthy activity, thereby aiding digestion. It is generally considered that horses and

cattle fed silage show the beneficial effects of this food in the more healthy condition of the skin, as evidenced in its pliable, mellow condition, and the softness and luster of the coat of hair. Animals usually eat sound silage with a relish, and reject it only when decay is present. For milch cattle it seems especially well adapted, and the silo has proved an important and economical addition to the dairy farm.

DAIRY CATTLE.

At the Wisconsin Station a daily ration of 4 pounds of hay and 7 pounds of grain with corn silage or field-cured corn fodder was fed to 20 cows for 16 weeks. During the silage feeding 19,813 pounds of milk were produced, and 19,801 pounds during the corn-fodder feeding. Taking into account the areas of land from which the fodder and silage corn were produced, it is shown that the silage would have produced 243 pounds more milk per acre than the dry fodder, or the equivalent of 12 pounds of butter, a gain of slightly over 3 per cent in favor of the silage.

At the Vermont Station silage gave favorable results with dairy cattle. The yield of milk was larger from silage than from corn fodder, but of slightly poorer quality, containing on an average 12.91 per cent solids and 4.05 per cent fat, while that from cows fed corn fodder contained 13.25 per cent solids and 4.28 per cent fat. The total yield of the milk constituents was higher with silage feed. Considering the yield of milk and butter fat from the two feeds, grown on equal areas of land, the result was favorable to silage at the rate of 8 per cent more milk, 5 per cent more solids, and 3 per cent more fat. One pound of dry matter in silage produced more milk and slightly more solids and fat in 6 out of 9 cases than 1 pound of dry matter in corn fodder.

At the Ohio Experiment Station, for four years in succession, comparisons were made of the relative influence of silage and beets in milk production. In comparing the results in pounds of milk produced for 100 pounds of dry matter consumed, it appears that in the general average of all experiments 100 pounds of dry matter had produced about 4 pounds, or, approximately, 6 per cent, more milk when the cows were fed on silage than on beets. The Pennsylvania Station, in similar experiments, corroborated the Ohio results.

In experiments on milch cows at the Massachusetts Experiment Station, silage, consisting of a mixture of corn and soy beans, proved itself to be fully equal if not superior to hay in producing milk, without affecting the quality, and at the same time decreasing the absolute cost. In other experiments at the Massachusetts Station comparisons were made of the influence of corn fodder, corn stover, corn silage, and English hay on milk production. The foods were fed with grain. As bearing on the cost of milk production, in every instance the cost was greatest where hay was fed. Whenever a part of the hay was replaced by either corn fodder, stover, or silage, the cost was mate-

rially reduced. When the corn fodder, stover, or silage was fed alone, the cost was likewise reduced, and at the prices charged little uniform advantage in favor of either food could be traced. In experiments extending over five years corn silage was fed most advantageously in place of one-fourth to one-half of the full hay ration. From 35 to 40 pounds of silage per day, with all the hay called for to satisfy the animal, in addition to the grain ration, seemed a good proportion.

The popularity of the silo with owners of dairy cattle has increased very greatly. Few owners of stock of this class, who have properly built silos and well preserved silage, would discard silage as an adjunct to feeding. Silage certainly promotes milk flow. One great argument in favor of its use lies in the cheapness of production per ton and the ability to store and secure a palatable, nutritious food in weather conditions that would seriously injure hay or dry fodder.

It is important that owners of milk cattle should bear in mind that when the silo is first opened only a small feed should be given. In changing from grass or dry feed to silage, if a regular full ration is given, the silage will perhaps slightly affect the taste of the milk for a few milkings, and if the change is from dry feed it may cause too great activity of the bowels.

In the earlier history of the use of silage for dairy cows objection was raised to it on the ground that it tainted or otherwise injuriously affected the milk. This subject was inquired into in England by a royal commission, the findings of which were that in a large majority of cases the yield, whether of milk or butter, was increased by feeding silage, and the quality of the product was also improved; and in but a very few cases were the results unfavorable. It is now generally recognized that, with the improved modern methods of using silage, and with proper precautions to prevent the milk after it has been drawn from the cow from being tainted with the objectionable odor of badly fermented silage, the material may be freely used without danger of injury to the quality of dairy products.

BEEF CATTLE.

Silage has not been fed so extensively to beef cattle as to dairy animals, but as a rule its feeding has been attended with success. Voelcker, at Woburn, England, fed 12 Hereford steers, one-half of them hay and grain and the other half grass silage and grain. The experiment extended over eighty days. At the beginning of this test the silage-fed animals weighed 2 pounds more than the hay-fed ones; at the end the former had gained 512 pounds and the latter 418 pounds—a gain per head daily for the silage-fed of 1.6 pounds, and 1.3 pounds for the hay-fed. It was estimated that it cost 4 cents more per pound of increase of dead weight produced on hay than it did for that produced on silage.

At the Indiana Station the writer fed 8 steers 42 days. Four steers

were given silage and grain and 4 clover hay and grain. The general health of each lot was good. Each steer fed silage gained on an average 1.75 pounds per day, while the clover-fed animals gained 1.4 pounds per day. At the end of the 42 days' feeding the silage-fed steers had gained in value $19.20, and the clover-fed $16.76, or $2.44 in favor of the silage-fed lot.

At the Wisconsin Station 4 steers were fed silage without grain and 4 silage with shelled corn and bran. The lot getting silage gained 222 pounds, while those fed grain in addition gained 535 pounds, or a gain of 1.5 pounds each per day for the first lot, and 3.7 pounds per day where grain was fed.

Mumford, of the Illinois Station, conducted an important silage-feeding experiment with 50 grade Hereford and grade Shorthorn steer calves on the Funk farm, in Illinois, for 88 days ending May 5, 1902. The steers were 8 months old at the beginning of the experiment, and there were 25 head in each lot. Lot 1 was fed silage, whole oats, and mixed hay. Lot 2 was fed shock corn in place of silage, the other food being the same as that fed lot 1. The silage-fed steers made a total gain of 3,693½ pounds and those fed on shock corn 3,133½ pounds—an average daily gain per head for lot 1 of 1.68 pounds and for lot 2 of 1.42 pounds. Commenting on the results, Mumford says:

> The average number of pounds of meat made per acre from feeding silage with oats and hay as supplementary feeds was 385.35, and from feeding shock corn with oats and hay, 337.91 pounds—a difference of 47.45 pounds per acre in favor of the silage. * * * The silage-fed steers were in much better thrift and flesh at the end of the experiment than the shock-corn fed steers. * * * In the case of the silage-fed steers 97.69 per cent of the meat produced was beef and 2.31 per cent pork. In the case of the shock-corn fed steers 84.22 per cent of the meat produced was beef and 15.78 per cent was pork. Pigs followed after each lot.

W. Stokes in 1899 reported in the Breeder's Gazette that for the past ten years he had fed from 150 to 250 steers annually on silage. Grade feeders weighing from 700 to 1,100 pounds were purchased in the late fall or early winter and fed from 90 to 150 days. The daily ration for cattle from 900 to 1,000 pounds was cotton-seed meal, 5 pounds; cotton-seed hulls, 8 pounds; silage, 40 to 50 pounds. The amount of meal and hulls did not vary. Silage was fed once daily in an open lot. The average gain for the steers ranged from 200 to 250 pounds. Sorghum silage was used. Mr. Stokes thinks the advantages from feeding silage to steers are many.

At the Texas Station dry corn fodder did not give as large gain as silage when each was fed with cotton-seed products. While 53 per cent of the corn fodder was rejected by the animals, only 8.2 per cent of the silage was refused.

At the Agricultural College at Guelph, Ontario, Canada, silage was compared with roots on 6 steers. The conclusion was reached that corn silage and meal will fatten as effectively and cheaply as a ration of roots, hay, and meal, and with less expenditure of labor.

In an experiment reported by H. E. Alvord, 90 3-year-old steers were divided into three lots as evenly as possible. Lot 1 was fed 20 pounds of hay and 3 pounds of grain per head daily, and allowed to run in a yard with sheds for shelter. Lot 2 was kept in a warm stable and fed 17½ pounds of hay, 15 pounds of mangel-wurzels, and 3 pounds of grain. Lot 3 was fed 85 pounds of silage and 3 pounds of grain, and confined in stanchions. Lot 3 gained one-fourth of a pound per head daily more than lot 2 and one-half pound more than lot 1. The cost of food was 5 per cent in favor of lot 3.

During the last few years beef feeders have begun to give more attention to the merits of silage as a food for steers, and its use is meeting with constantly increasing favor in the Central West. While silage should not be fed fattening cattle as liberally as to dairy cows, it is a most valuable feeding stuff in beef production, and will give good returns where fed with judgment.

HORSES.

It is not the general practice to feed silage to horses, but in numerous cases it has been fed to them with success.

When silage was first introduced, numerous instances occurred of injury resulting from feeding it to horses. This was probably due to giving too large an amount for the small stomach of the horse. This caused colic or some similar trouble. The writer knows of several cases where horses have died when fed silage, but it could not be demonstrated that the silage was at fault, though suspicion pointed that way. This food when very acid should be fed to horses only in a limited way. In discussing this question, Stewart notes that there have been many fatal cases of stable horses eating too much grass. Evidence is strong that grass has caused fatal results as often as silage. The change from dry feed to grass or silage must be very gradual. Stewart fed silage to four horses for two winters, adopting the same precautions as he would in feeding grass, the results being quite satisfactory.

Alvord states that mules have been kept almost exclusively on silage, and notes a case of a large farmer and grape grower in North Carolina who has for several years made silage of cowpeas and used it as the chief forage for a number of mules kept constantly at work. In this case it was found an economical and desirable food.

The Royal Commission, which made an investigation of the merits of silage in England, reported:

> Strong as the evidence has been of the advantage of silage for keeping stock in healthy condition, the farm horses have by no means been excepted. We have received highly satisfactory accounts from several quarters of the health of working teams when given a limited proportion of silage mixed with other food.

At the agricultural experiment stations but few feeding experiments of any kind have been attempted with horses, and in this work silage

has played but a small part. At the Ohio Station about 20 pounds of silage per day was fed to horses instead of hay during February and March. The result appeared beneficial as indicated by increase of appetite and improvement in the spring coat of hair. Nourse at the Virginia Station fed two horses and six mules silage with satisfactory results, though they would not eat freely of it.

Among the most important evidence unfavorable to the use of this food for horses is that from M. W. Dunham, of Wayne, Ill., a large horse breeder and importer. In a letter to the writer, dated May 17, 1895, he says:

> I put up silage two years for feed for my horses, but the results were so unsatisfactory that I discontinued its use. I don't consider it fit feed for them.

Although considerable testimony is at hand showing that silage has been fed to horses with success, the indications are that its use can be recommended only when fed to a limited extent in connection with hay, straw, or corn fodder.

SHEEP.

As with steers, the use of silage as a food for sheep has in recent years met with more and more favor. To-day there are extensive feeders who employ silage as an important part of the daily ration. Mr. A. M. Welsh, of Michigan, has for some years made a specialty of feeding fattening lambs in large numbers on silage and with signal success. Mr. Welsh, in a letter published in the Farmers' Gazette (November 4, 1899), says: "There will be close on 10,000 lambs fed on silage in Ionia County this season."

Extensive experiments in feeding lambs were carried on in 1892–93 at the Michigan Station. One hundred and twenty-five lambs were divided into 10 lots, each lot being as uniform as possible, and 10 different rations were fed. Lot 9, that received silage, ranked third in the economy of the cost to produce 1 pound of gain. In comparing one lot fed roots with another fed silage, each lot made the same gain, but the profit on those fed roots was 22 cents on each lamb, while those fed silage gave a profit of 63 cents. This result corroborated previous experience at this station.

At Cornell University 2 lots of ewes in milk were fed for 2 years in succession, one lot receiving mangel-wurzels, the other corn silage with the grain in it. In addition to the above foods, one lot was fed a mixture of 2 parts of bran, 1 part of corn meal, and 1 part of cotton-seed meal. The roots and silage were fed once a day and the ewes were given all they would readily eat. The ewes fed on the silage ate it in a satisfactory manner, and ate a little more grain than did the sheep fed on beets, though hardly enough more to denote a greater appetite due to silage. The early lambs sucking silage-fed ewes, for both years, averaged a gain of 3.49 pounds a week, while those sucking root-fed ewes gained 3.33 pounds per week.

At the Wisconsin Station wether lambs were fed several different rations. Silage from both corn and clover was fed in special cases.

The corn and the clover silage proved to be good additions to the rations. They apparently had the effect of keeping the digestive organs of the wethers in healthy condition. The corn silage, considering its conduct as a food, and the fact that it can be preserved cheaper and better than the clover silage, was the most satisfactory.

In another experiment it was found that—

Of the succulent fodders, the best results were obtained from feeding corn silage. It is cheap, the ewes like it, and they can easily be kept in a healthy condition when it forms part of the ration. The only danger lies in the fact that it may contain too much corn for breeding ewes. Next to it come sugar beets, and lastly the clover silage, which was not eaten as eagerly as either of the other fodders, and the amount of refuse was greater and the cost higher.

At the Massachusetts Station 6 sheep were fed during one period a ration of gluten feed, cotton-seed meal, and second-crop hay (rowen). After feeding this ration, corn and soy bean silage was substituted for the hay and fed 7 weeks. The difference in gain in weight in one period over the other was very slight, being 2.5 pounds in favor of the hay for the 2 sheep for 7 weeks. The silage ration, however, cost $5.58 as compared with the $6.26 for the hay, and it cost more to make a pound of gain with the hay than with the silage.

E. K. Seabury, of New Hampshire, states that he is very positive that no one need hesitate a moment in feeding silage to sheep and that he can furnish abundant testimony from good practical men that it is as good for sheep as for cattle. He also reports that certain prominent breeders of Merino sheep in Vermont have fed their sheep largely on silage with satisfactory results.

There seems to be but little testimony unfavorable to the use of silage for sheep, and there is no reason why it should not be fed to a reasonable extent instead of roots. The feed, however, should not be exclusively silage, but this should be fed as an addition to grain and hay.

SWINE.

Numerous attempts have been made to feed swine silage, but generally without success. In some cases swine have gained something probably from the grain that might be present in the silage, but the available data do not as a rule demonstrate satisfactory results from such feeding. The Utah Station reports, as a result of experiments, that silage is unfit for pigs and that they do not like it. At the New York State Station feeding experiments in this line have yielded entirely unsatisfactory results. Henry reports that he has repeatedly tried corn and clover silage as a food for swine, but without success. The Virginia Station, however, reports fairly successful results from using silage in connection with corn as a cheap maintenance ration for carrying brood sows over winter, but not for fattening.